

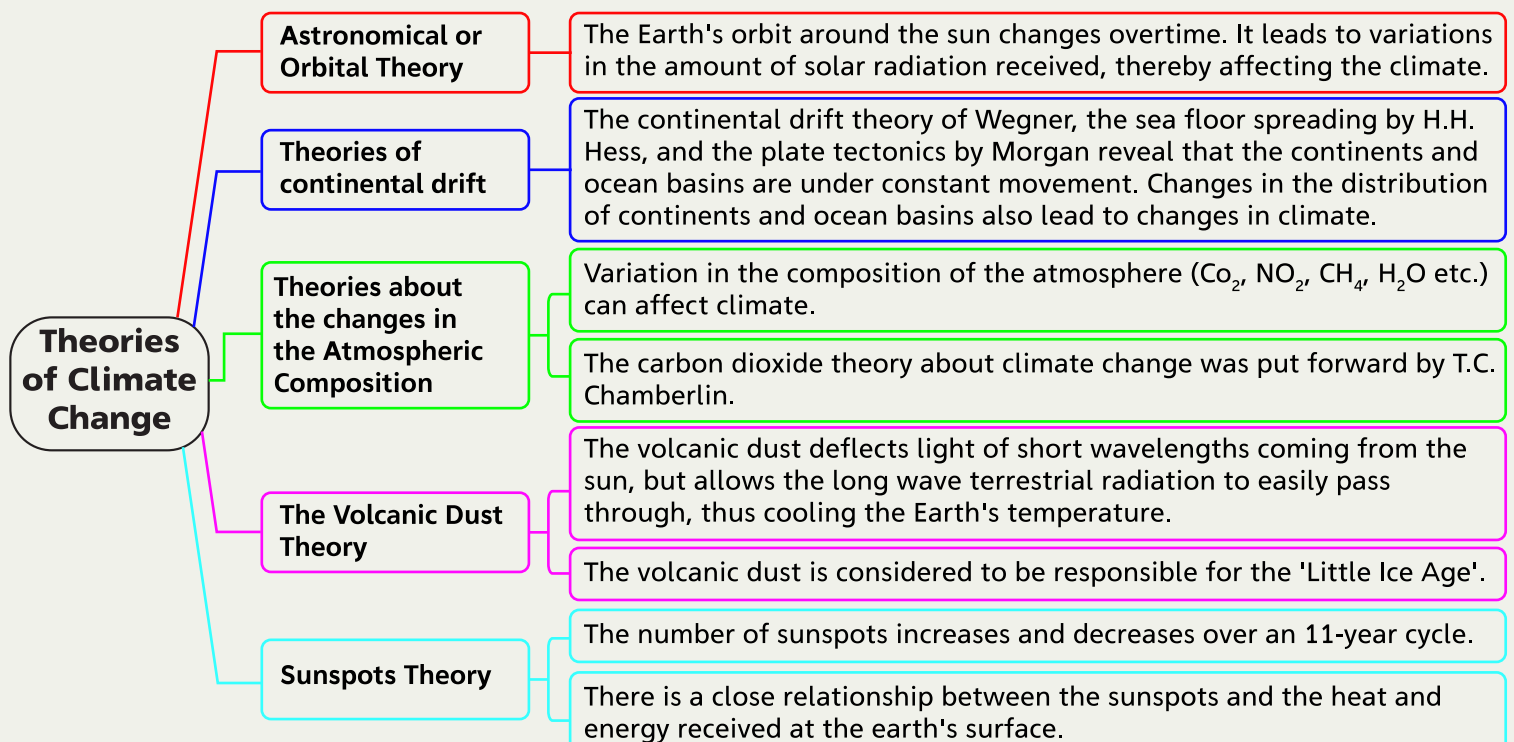


# CLIMATE CHANGE & GLOBAL WARMING

## What is Climate Change?

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

## Theories of Climate Change



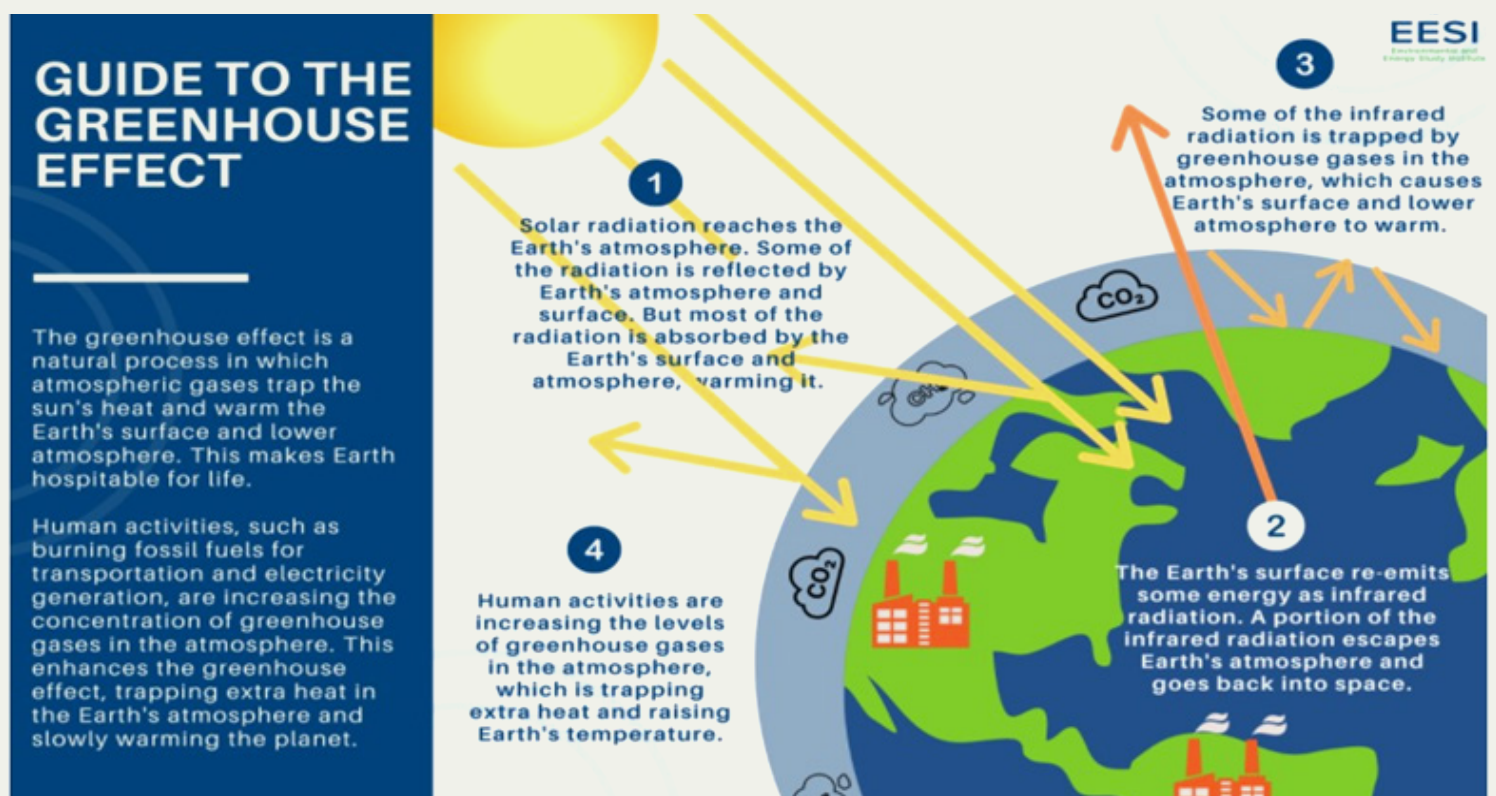
# Climate Change Drivers



## Greenhouse Gases and Global warming: Green House Effect, Sources & Causes and Evidences

### What is Global warming?

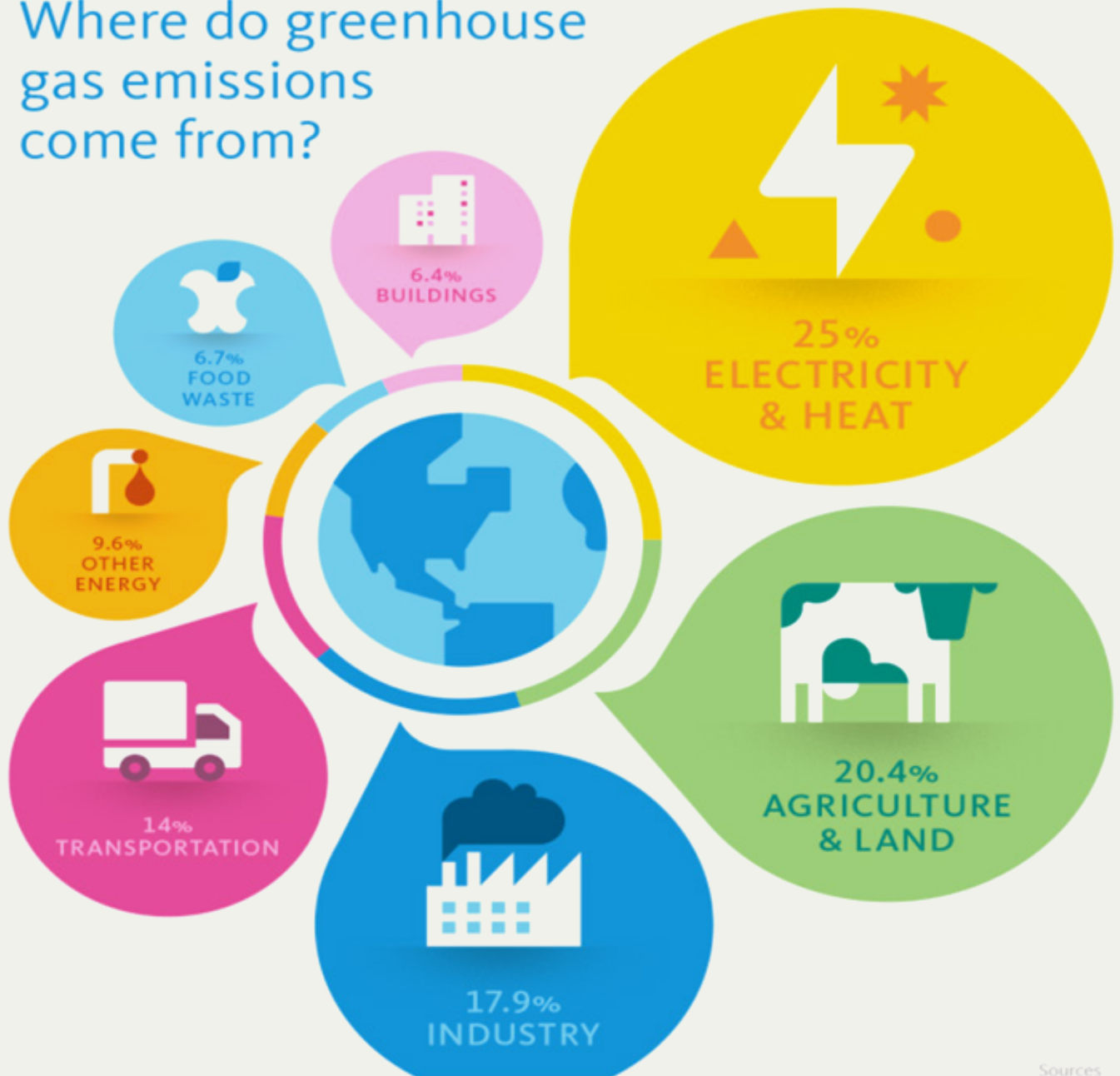
Global warming refers to the increase in average global temperature since the Industrial Revolution. The average global temperature has increased by about one degree Celsius since 1880. Global warming is an ongoing process; scientists expect the average global temperature to rise an additional 0.3 to 0.7 degrees Celsius through 2035.



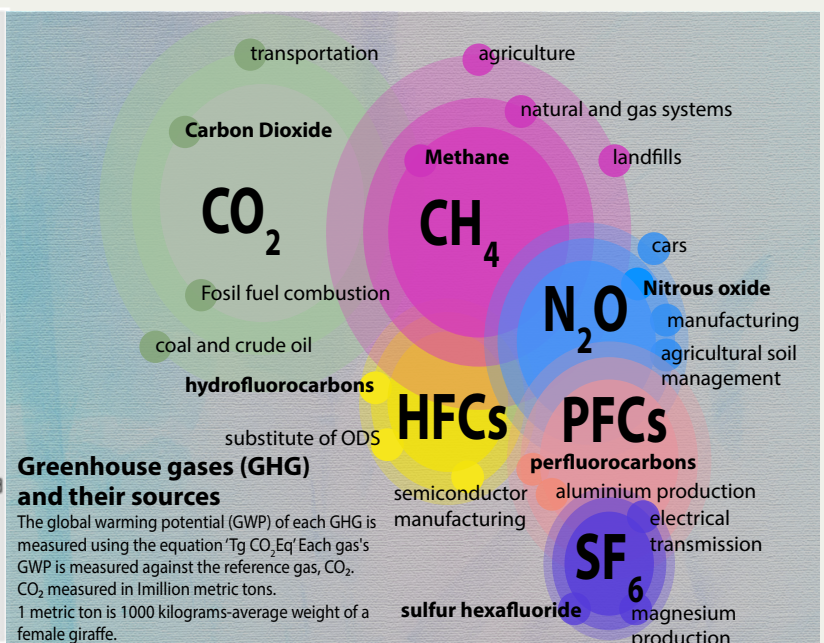
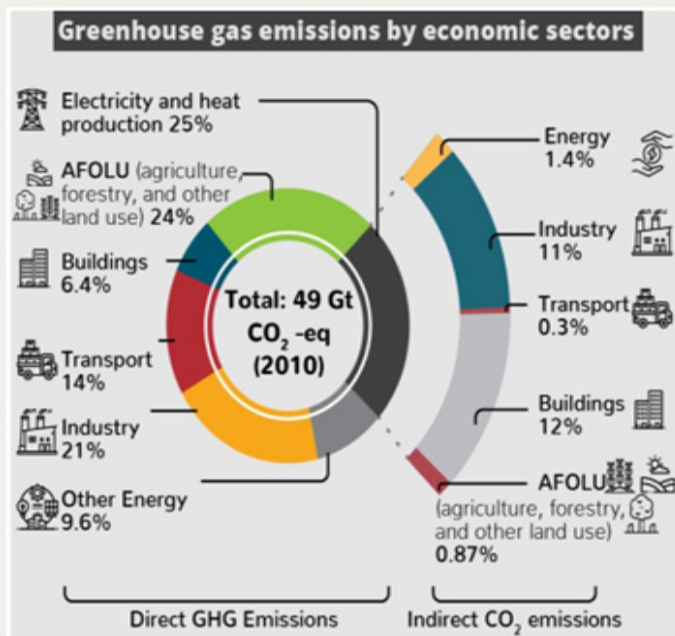


# Greenhouse Gases: Sources and Causes

Where do greenhouse gas emissions come from?

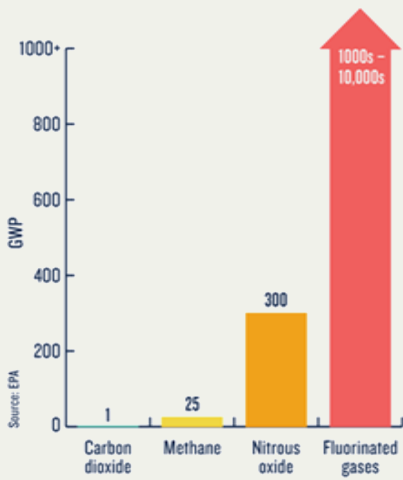


Sources

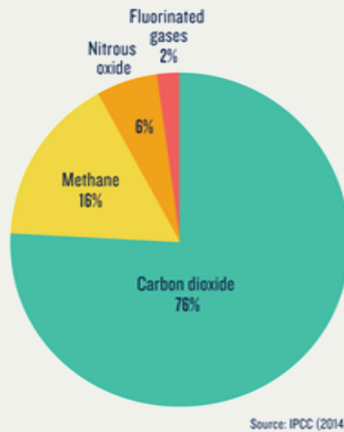


# Global Warming Potential (GWP):

## HOW GREENHOUSE GASES WARM OUR PLANET



The global warming potential (GWP) of human-generated greenhouse gases is a measure of how much heat each gas traps in the atmosphere, relative to carbon dioxide.



How much each human-caused greenhouse gas contributes to total emissions around the globe.

The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases.

It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO<sub>2</sub>).

The larger the GWP, the more that a given gas warms the Earth compared to CO<sub>2</sub> over that time period. The time period usually used for GWPs is 100 years.

Greenhouse Gases	Atmospheric lifetime (yrs)	GWP	Sources/Causes
Carbon Dioxide (CO <sub>2</sub> )	50-200	1	Burning of fossil fuels, deforestation
Methane (CH <sub>4</sub> )	12 ± 3	21	Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuels, wood, landfills.
Nitrous Oxide (N <sub>2</sub> O)	120	310	Burning of fossil fuels, fertilizers; burning of crop residue
Hydrofluorocarbons (HFCs)	1.5 to 209	150 to 11700	Primarily produced for use in refrigeration, air-conditioning, insulating foams and aerosol propellants
Perfluorocarbons (PFCs)	2600 to 50000	6500 to 9200	The aluminum smelting industry has been a major source of atmospheric perfluorocarbons.
Sulfur Hexafluoride (SF <sub>6</sub> )	3200	23900	SF <sub>6</sub> is a substance which originates only from anthropogenic sources used primarily in the electricity and electronics supply industries, e.g., the semiconductor industry, where it is used as an electronic insulator due to its inertness.

## Global warming evidences

### ○ Atmosphere

- It is observed that globally the troposphere has warmed and the lower stratosphere has cooled since the mid-20th century.
- precipitation has likely increased since 1901.

### ○ Ocean

- Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 with only about 1% stored in the atmosphere.
- the ocean warming is largest near the surface period.

### ○ Cryosphere

- Greenland, Antarctic ice sheets, Arctic Sea ice extent and glaciers continue to shrink globally.

### ○ Sea Level

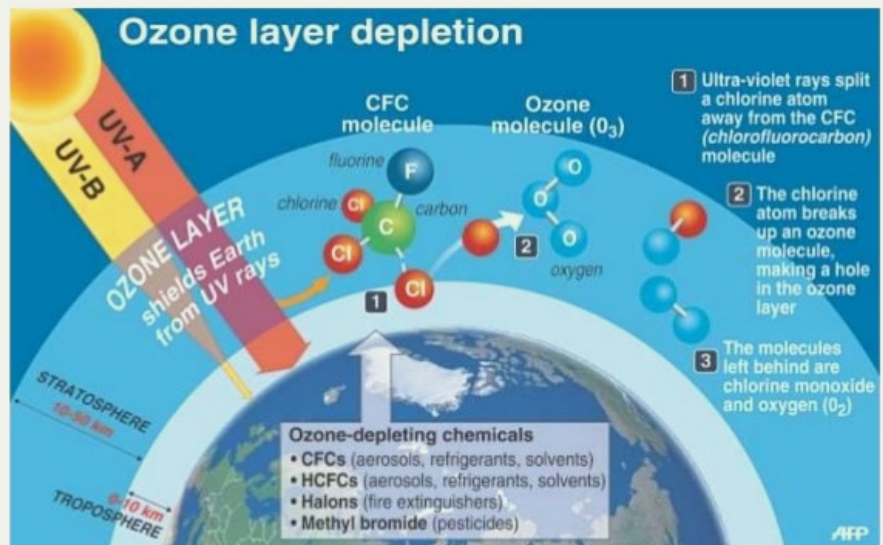
- Over the period 1901–2010, global mean sea level rose by 0.19m.

### IPCC Report: SROCC (Findings on Changing Climate)

<b>High-mountain regions</b>	<ul style="list-style-type: none"> <li>By the end of the century, glaciers are projected to lose around 18% of their mass compared to 2015 levels under a low-emissions scenario and around a third under a high-emissions scenario.</li> </ul>
<b>Sea Ice at the Earth's poles</b>	<ul style="list-style-type: none"> <li>Arctic surface air temperatures over the past two decades have increased at more than double the global average. This rapid phenomenon is known as "Arctic amplification".</li> <li>In contrast, the Antarctic continent has seen less uniform air temperature changes due to Southern Ocean Circulation.</li> </ul>
<b>Permafrost</b>	<ul style="list-style-type: none"> <li>Permafrost is defined as "ground (soil or rock containing ice and frozen organic material) that remains at or below Zero degrees Celsius for at least two consecutive years".</li> <li>By 2100, near surface permafrost area will decrease by 2-66% and 30-99% under various projections.</li> </ul>
<b>Oceans</b>	<ul style="list-style-type: none"> <li>The current rate of Sea Level Rise (SLR) is now larger than the mean rate of the previous two millennia.</li> <li>Increase in ocean stratification.</li> <li>Growth of Oxygen Minimum Zones.</li> </ul>

- The main reason of ozone layer depletion is believed to be the release of chlorofluorocarbon compounds (CFCs), also known as freons.
- Once CFCs are released in the atmosphere, they mix with the normal atmospheric gases and eventually reach the stratosphere. In stratosphere, they get broken down by powerful UV radiations, releasing chlorine free radical. The chlorine radicals are continuously regenerated and cause the breakdown of ozone.

### What is ozone depletion?



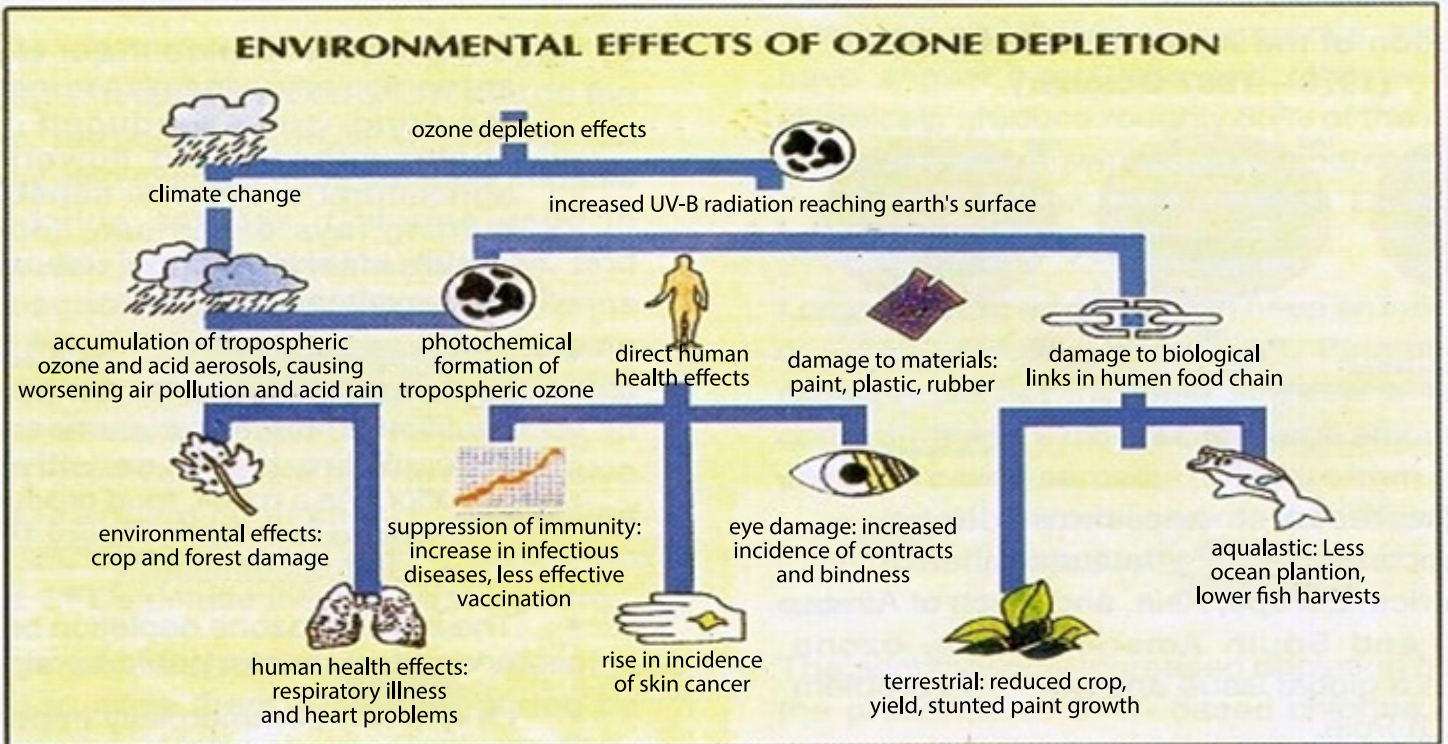
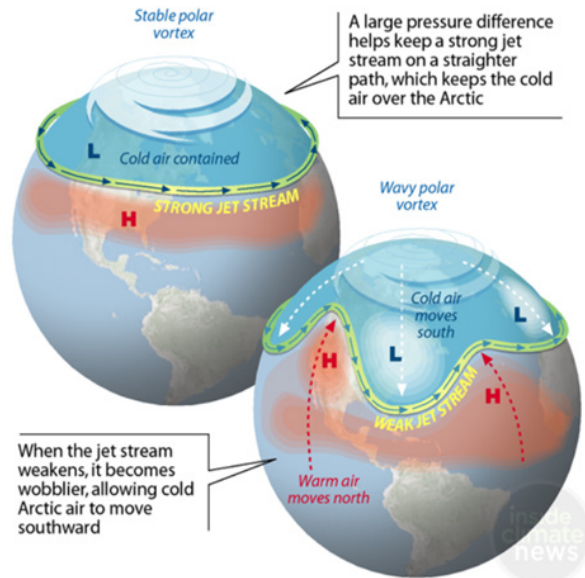
Ozone- Depleting Substances	Sources
Chlorofluorocarbons	Manufacturing of polyurethane, phenolic, polystyrene and polyolefin foam polymers, blowing agents
Halons	Used in portable fire extinguishers.
Hydrochlorofluorocarbons (HCFCs)	Used in the refrigeration, foam, solvent, aerosol and firefighting sectors as a transitional substance to substitute CFCs.
Methyl Bromide	Used as a fumigant in agriculture, for pest control in structures and stored commodities, and for quarantine treatments.
Carbon Tetrachloride	Used as chlorinated solvent in different industries, feedstock for different CFCs.
Methyl Chloroform	Used for cold cleaning, vapour degreasing, chemical processing, adhesives in industries.
Nitrogen Oxides	Explosions of thermonuclear weapons, industrial emissions and agricultural fertilizers.

## Role of Polar Stratospheric Clouds

- In 1980s atmospheric scientists working in Antarctica reported about depletion of ozone layer commonly known as ozone hole over the South Pole. It was found that a unique set of conditions was responsible for the ozone hole.
- In summer season, nitrogen dioxide and methane react with chlorine monoxide and chlorine atoms forming chlorine sinks, preventing much ozone depletion.
- In winter, special type of clouds called polar stratospheric clouds are formed over Antarctica. These clouds provide surface on which chlorine nitrate formed gets hydrolysed to form hypochlorous acid. It also reacts with hydrogen chloride produced to give molecular chlorine.

## Polar Vortex Explained

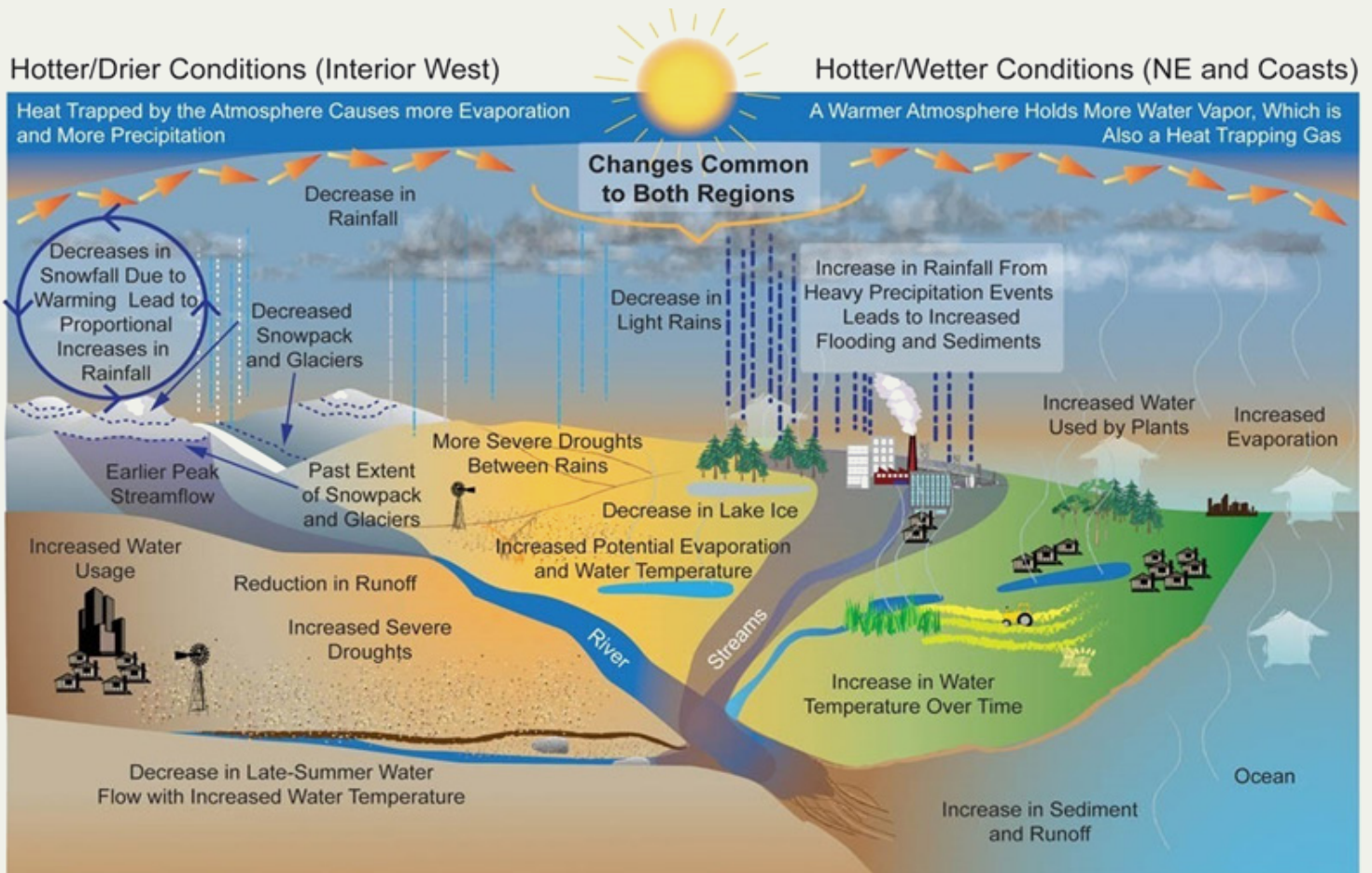
The polar vortex is a large area of low pressure and cold air over Earth's North and South Poles. When the jet stream weakens, it becomes wavier, allowing that cold air to dip southward in places while warmer air pushes northward elsewhere.



## Consequences/ Impacts of climate change:

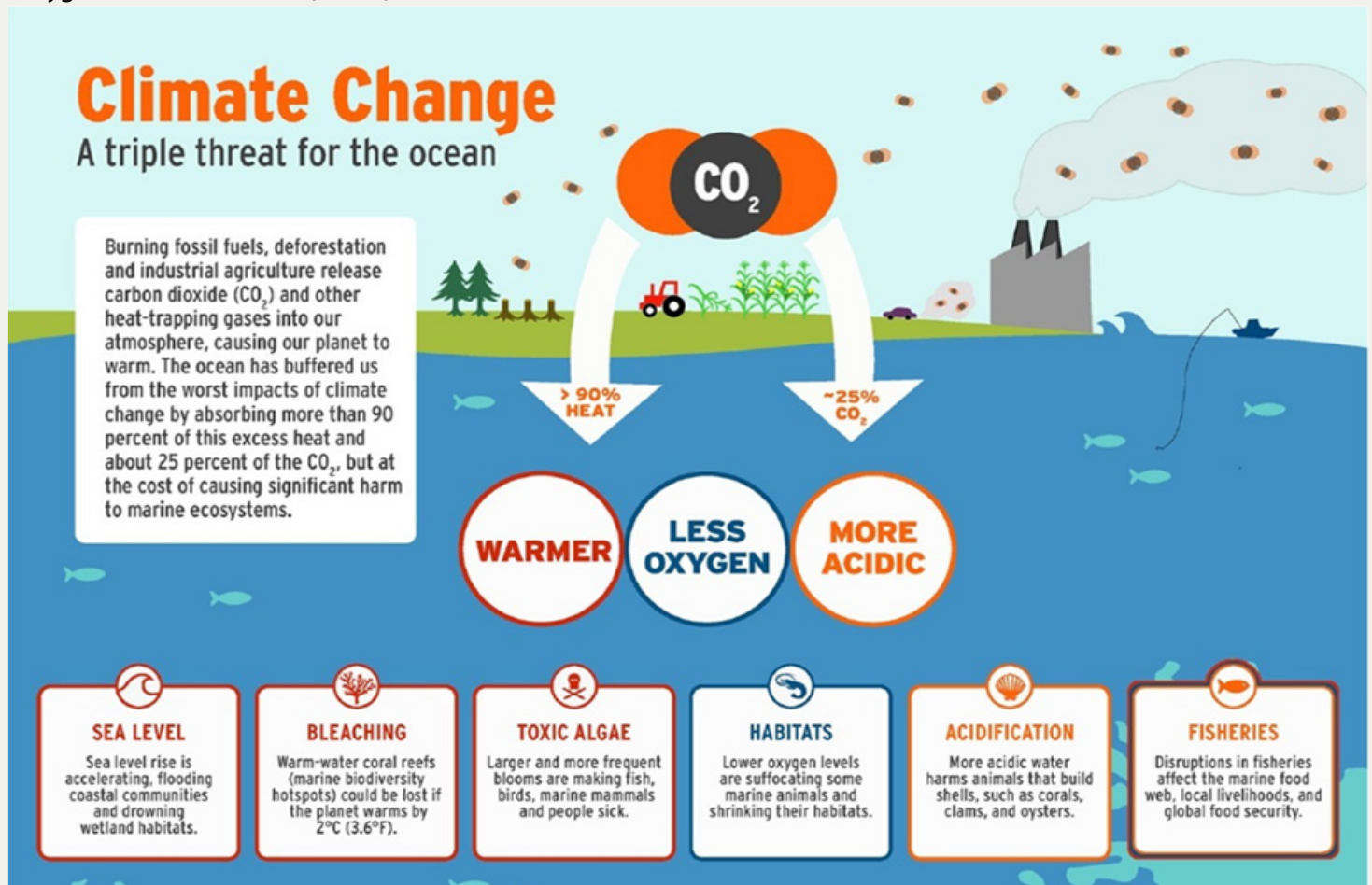
### Impact on Hydological Cycle

1. Reduced availability of water resources/ Serious threat to water security.
2. Agriculture: Water demand for crops and livestock will be affected. Affecting the crop yield in both irrigated and rainfed regions.
3. Energy Production: Climate change increases streamflow variability thus affecting the hydropower generation.
4. Municipal Services: Increased temperature can also encourage presence of algal bloom and cyanotoxins thus needing additional and new treatment methodologies.
5. Freshwater Ecosystem: Between 1970 and 2000, populations of freshwater species included in the Living Planet Index declined on average by 50%.

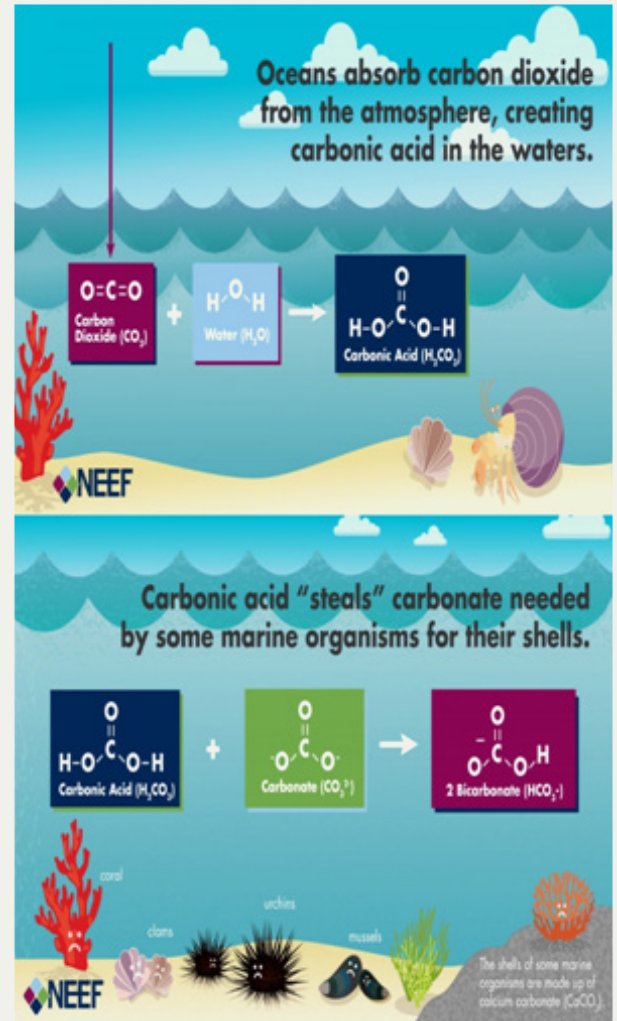
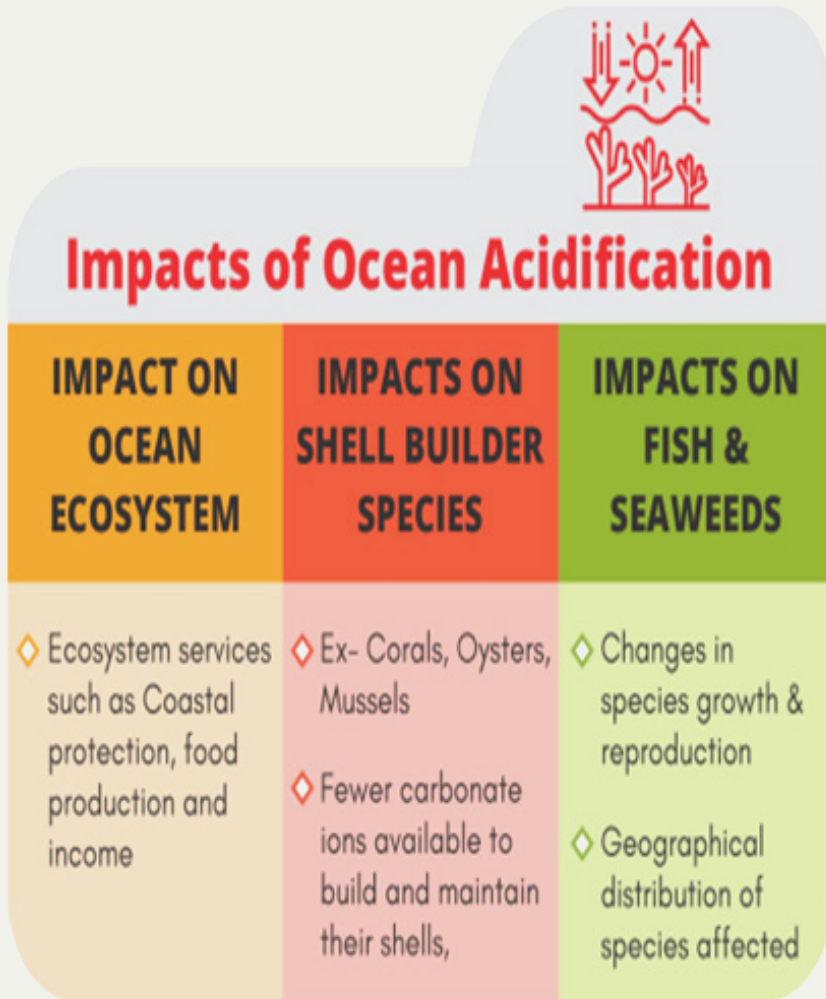


## Impact on Oceans

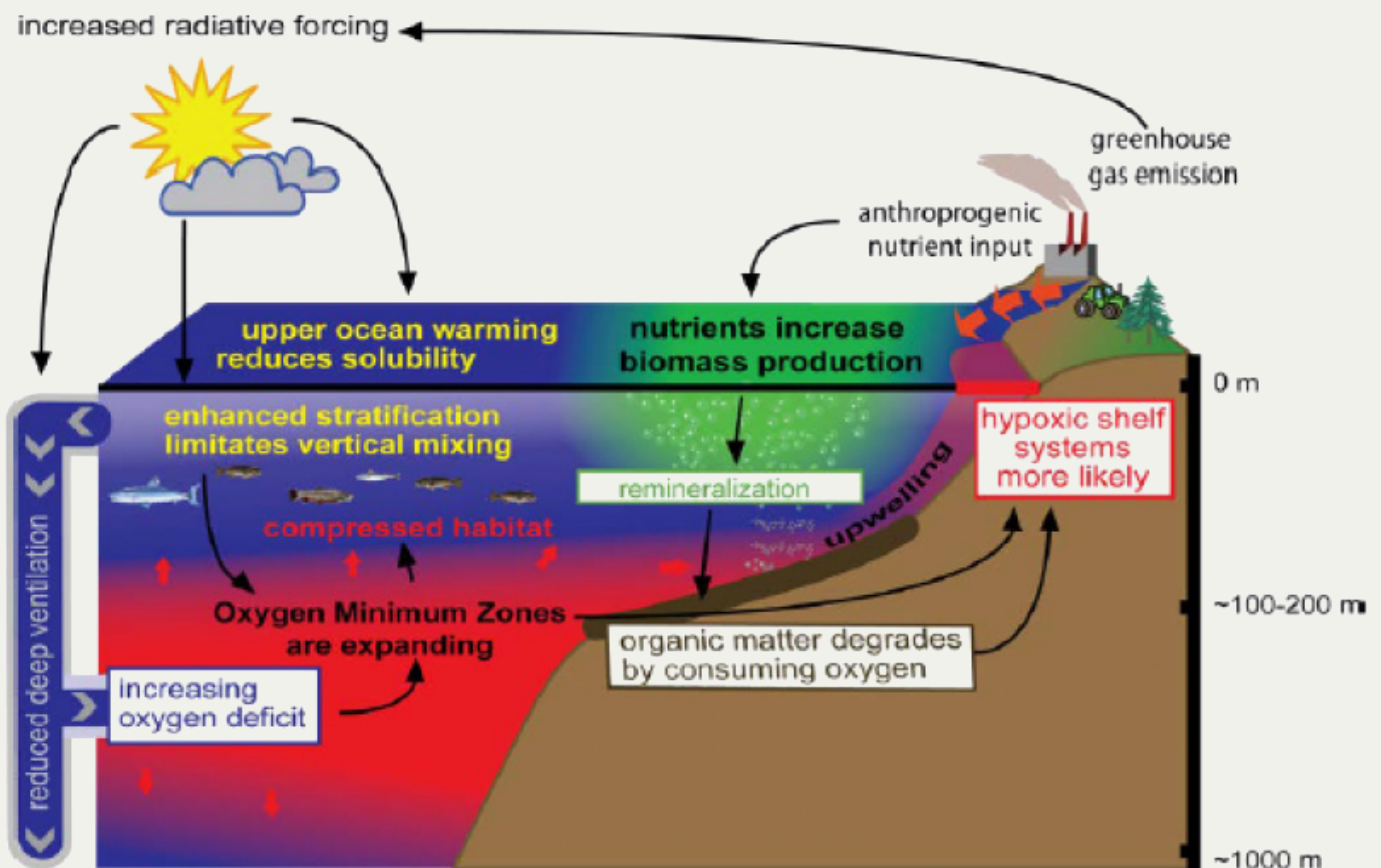
- **Ocean warming:** Climate Change leads to more stable stratification of layers by density. Which promotes more Oxygen Minimum Zones (OMZs)



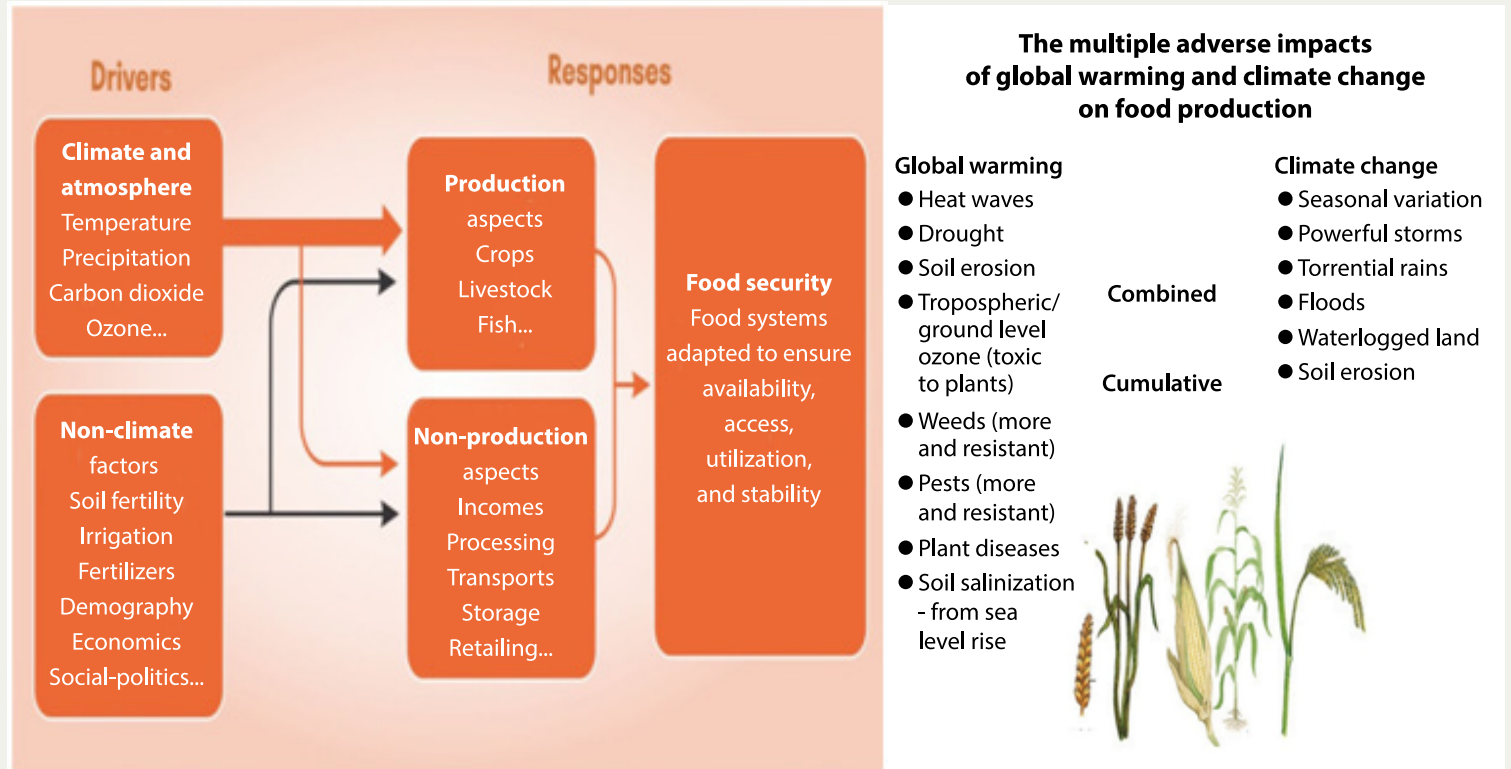
- **Ocean Acidification:** Anthropogenically emitted CO<sub>2</sub> gets dissolved in the sea water. It forms Carbonic Acid in the process, reducing the pH of water.



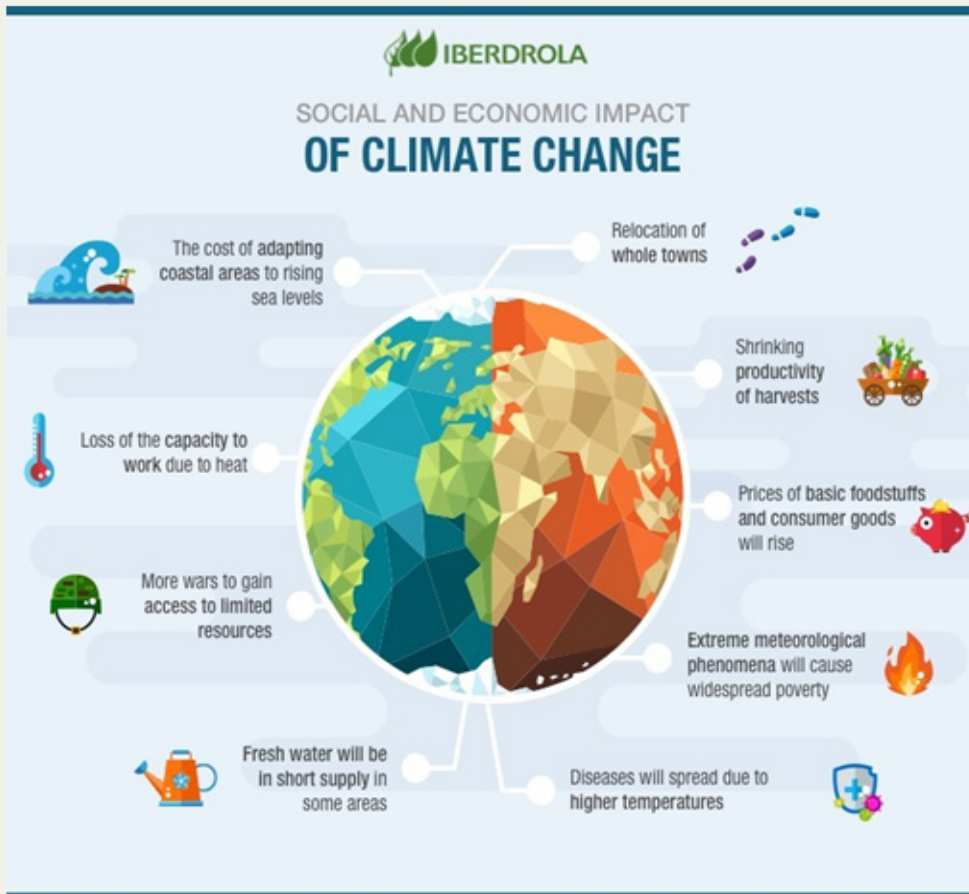
- **Ocean Deoxygenation:** Volumes of areas depleted of oxygen, known as "anoxic waters. Major causes include - degassing due to warming of sea water and less intermixing due to stable stratification of layers e.g. Baltic Sea and Black Sea.



# Impact on Food Security



# Socio-Economic Impact of Climate Change

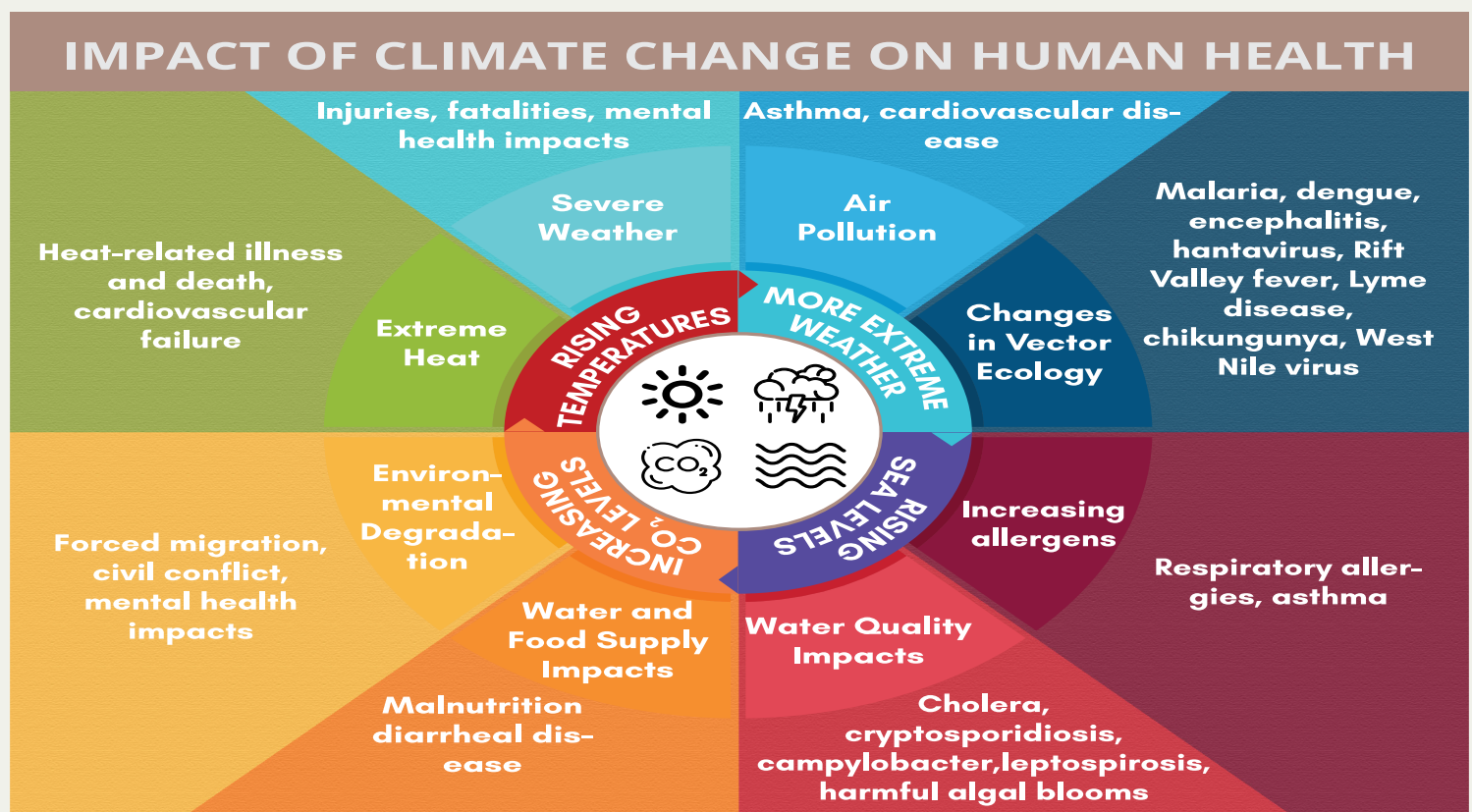


Sector	climate change drivers	Sensitivity to climate change	Sign	Other drivers
Cooling demand	<ul style="list-style-type: none"> <li>● Temperature</li> <li>● Humidity</li> <li>● Hot spells</li> </ul>		Positive for suppliers Negative for consumers	<ul style="list-style-type: none"> <li>● Population</li> <li>● Income</li> <li>● Energy prices</li> <li>● Technology change</li> </ul>
Health services	<ul style="list-style-type: none"> <li>● Temperature</li> <li>● Precipitation</li> </ul>		Positive for suppliers Negative for consumers	<ul style="list-style-type: none"> <li>● Aging</li> <li>● Income</li> <li>● Diet/lifestyle</li> </ul>
Transportation	<ul style="list-style-type: none"> <li>● Temperature</li> <li>● Precipitation</li> <li>● Storm Intensity</li> <li>● Seasonal Variability</li> <li>● Freeze/Thaw cycles</li> </ul>		Negative for all users Positive for transport construction industry	<ul style="list-style-type: none"> <li>● Population</li> <li>● Income</li> <li>● Urbanization</li> <li>● Regulation</li> <li>● Mode Shifting</li> <li>● Consumer and commuter behavior</li> </ul>

# Impact of Climate change on Gender and Security



# Impact on Human Health and Security



# Impact On Urban and Rural Areas

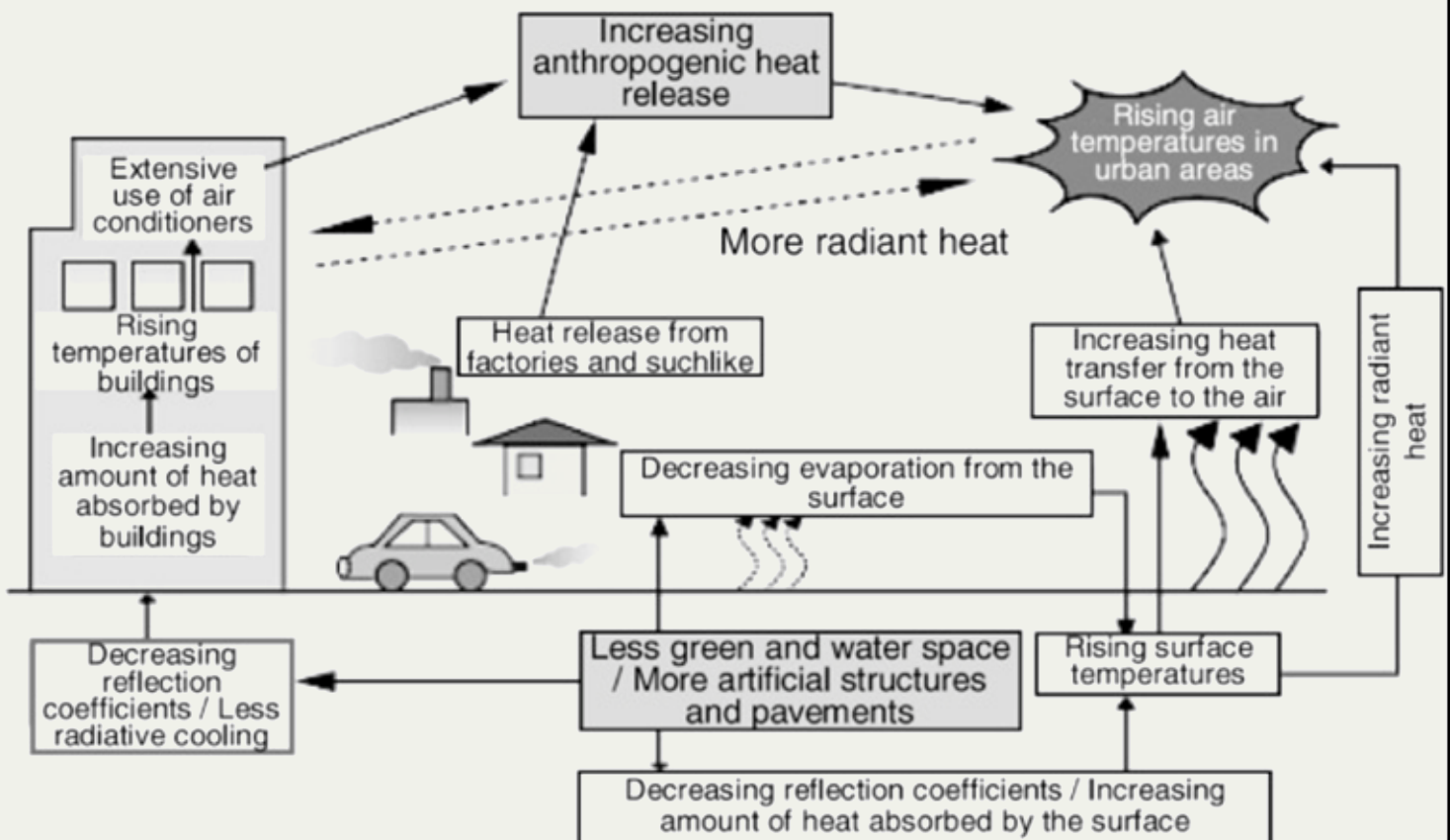
## On urban Areas

- Urban temperature variation: Increased frequency of hot days and warm spells will exacerbate urban heat island effects.
- Drought and water scarcity
- Coastal flooding, sea level rise
- Inland flooding
- Urban Heat Islands (UHI)

## On urban Areas

- It will affect rural livelihood as they are dependent mostly on natural resources.
- Loss of land and disruption to transport.
- Increased migration
- Increased intensity of knowledge diffusion.

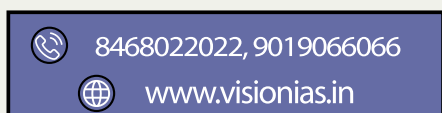
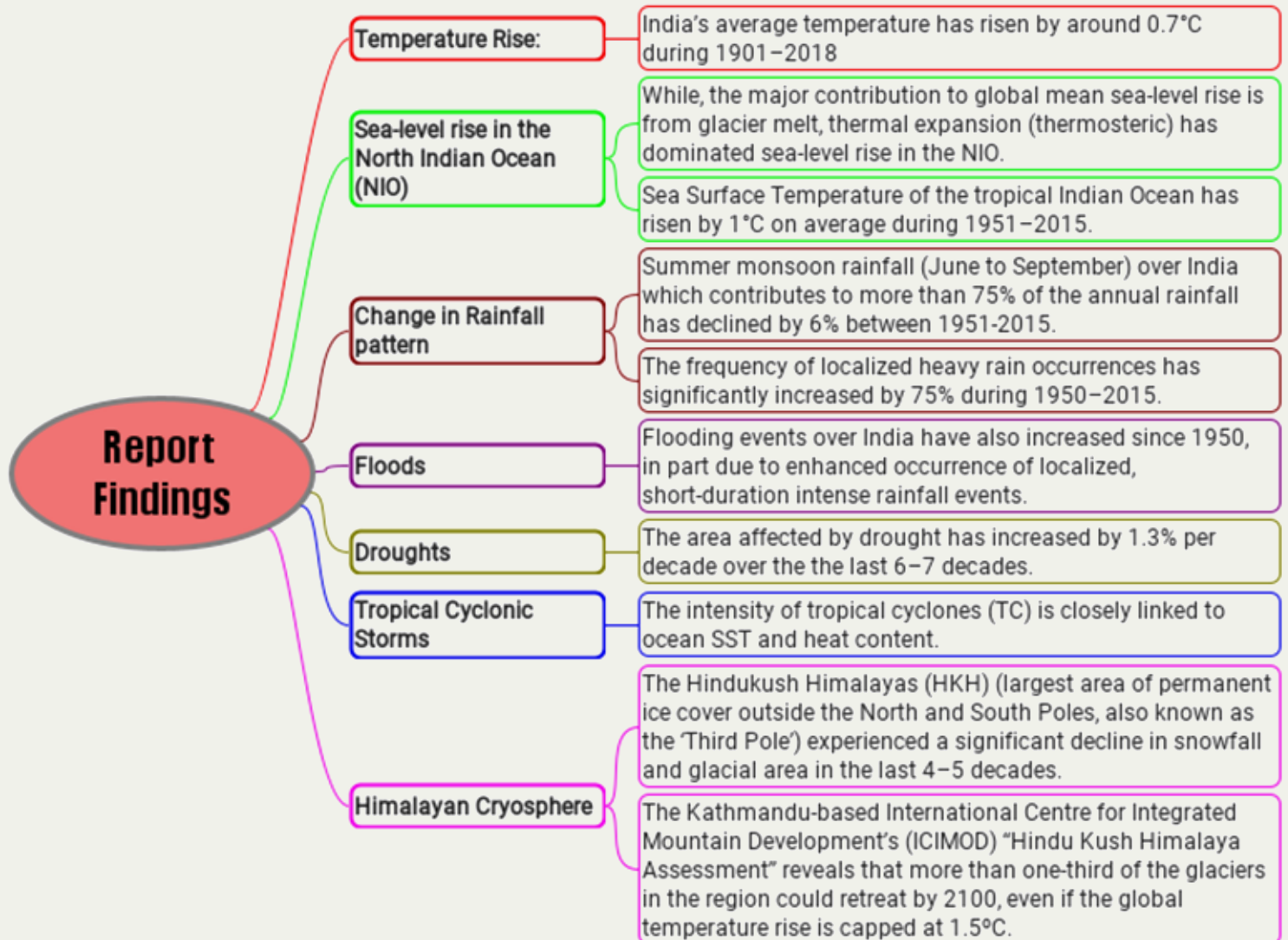
## How the urban heat island effect occurs





# Changes in Climate in the Indian Region

The Ministry of Earth Sciences' (MoES) has come up with the report titled 'Assessment of Climate Change over the Indian Region'. As per the report, following are the observed and projected changes in various climatic dimensions over the Indian region:



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DELHI



LUCKNOW



JAIPUR



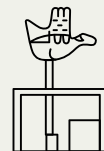
HYDERABAD



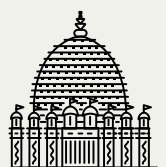
PUNE



AHMEDABAD



CHANDIGARH



GUWAHATI